MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

# PERFORMANCE EVALUATION FOR DIRECT FIRE SYSTEMS (U)

RICHARD C. SCUNGIO, JULIAN A. CHERNICK
US ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ABERDEEN PROVING GROUND, MD 21005

Historically, the item level performance of a weapon system has been expressed in terms of the firepower characteristics of the weapon. The weapon characteristics normally included in the computation of firepower were range, accuracy, lethality, and rate of fire. With the introduction of more sophisticated weapons, an awareness of the need to include additional factors in the assessment of a weapon's performance has emerged at both the decision and research and development levels.

This awareness has resulted in the development of a methodology permitting better understanding of the operational performance of a weapon system, especially concentrating on the battlefield environment and its possibly degrading effects. The methodology is patterned after a model which was originally developed to evaluate the performance of the 155mm laser-guided COPPERHEAD artillery projectile. Analyses performed with this method are identified as being "COPE" type analyses and are primarily designed to evaluate the performance of systems requiring uninterrupted line-of-sight between the attacker and the target.

The operational performance of direct fire systems is affected by many factors which can combine in one manner or another and influence the utility of the system on the battlefield. The methodology developed requires the identification of the influence of each factor on the employment or performance of the particular weapon system being evaluated. Initially an employment concept must be available to permit identification of the location of the weapon on the battlefield, especially related to the anticipated enemy advancement.

From this information, the anticipated ranges of engagement and the corresponding periods of target unmask can be identified. Weapon or projectile performance characteristics usually in the form of engagement ranges, accuracies, and lethalities are needed; if pertinent, these data should be correlated to weather condition. The effects of terrain, as it influences target movement and intervisibility, is included. The presence of vegetation and its effect on intervisibility is also reflected in the methodology. For a system such as COPPERHEAD, communications, command, and control and the problems inherent in a designator operator's fire request being answered in a timely manner to engage moving targets is portrayed. For other systems such as tanks or anti-tank guided missiles, this factor is not pertinent and therefore, not included. Enemy fire and counter fire and its obscuration and lethal effects are also considered when assessing operational performance. These factors combine to reflect what is a realistic environment for the analysis of a weapons system's operational performance.

A COPE type analysis exhibits certain characteristics. It is basically one-sided. Provisions are included in the methodology to evaluate the effects of enemy direct and indirect fire and their obscuration and lethal effects, however, it is not two-sided in the sense of a force-on-force model. The model uses probability density functions as input, reflecting the frequency of occurrence of the many factors influencing performance. As such, it is stochastic in its approach. All performance factors are combined in the methodology resulting in a tool which is very easy to test the sensitivity of total performance to variations in one or more factors. However, the most noteworthy characteristic of the methodology is its simplicity. The output is quite transparent, giving results which are easy to understand and interpret.

The events influencing the performance of a weapon system are interwoven within the methodology, producing estimates of the chance of successfully surmounting each factor. Four critical events, selected for their tactical significance, aid in applying the output of the model. These critical events are:

1. The occurrence of an occasion,
2. The attempt to engage a target,
3. The actual engagement of the target, and
4. The end of the mission.

The methodology assumes that an occasion occurs once a target breaks terrain shielding. Once this occurs, the conditions for success



248

must be satisfactory for seven factors before an engagement is attempted. These factors constitute a set of conditions within which the observer has survived, is able to detect the target, and the target is within the employment range of the weapon system. Once the designator operator requests fire, he must establish communications and line-of-sight must exist before a round is fired. If the methodology determines that these two factors are satisfactorily met, one or more rounds are fired and seven additional factors are evaluated prior to the determination of a target kill.

The last critical event, the end of the mission, occurs when all rounds have been fired or at the cessation of available target vehicles due to their passing out of line-of-sight or attrition.

To interpret the results of the model, four measures of performance are developed. These measures are:

1. The probability of attempting an engagement given an occasion occurs,

2. The probability of firing a shot given an engagement is attempted,

3. The probability of killing a vehicle given a shot is fired, and

4. An overall measure of operational utility which combines the effects of all the performance factors.

The methodology has produced quantitative estimates of the degrading effects of environmental factors which previously have been treated mostly qualitatively. In general, it has been found that the most serious degrading factor influencing the utility of a direct fire weapon system when engaging moving vehicles is the obscuration effects of smoke and dust raised by supportive fires. Given that the decision is made to engage a target, a shot usually follows, however, the probability of killing a target is usually lower than fire power estimates would have estimated. The most serious degrading factor influencing the weapons kill probability given a shot is fired, has been found to be the loss of line-of-sight to the target during the flight of the missile or projectile.

Comparisons have been made of the relative performance of COPPERHEAD, tanks, TOW and HELLFIRE when engaging targets in relatively open and close terrain.



249

Due to their relatively shorter ranges, tank and TOW do not attempt as many engagements as COPPERHEAD and HELLFIRE, however, due to their shorter reaction time, they are more likely to get a shot off once the decision is made to engage. The longer engagement ranges also affect the $P_{K/SHOT}$ for tanks and TOWs as they fall below the other systems with this measure. The measure of operational utility shows that HELLFIRE outperforms all systems in the open terrain case, with tanks and TOW being the least preferred. One factor has been omitted from the HELLFIRE evlauation to date, which probably produces a favorable estimate of performance, that is, the likelihood of a helicopter being available and properly located for the engagement. Current evaluations assume that an AAH is on station and assesses performance from that point.

For terrain which can be classified as being close, thereby affording short periods of intervisibility at short ranges, tanks outperform TOW and COPPERHEAD.

The methodology is such that it produces results which are intuitively appealing and permit the direct comparison of various weapon systems. However, its greatest value and the way that it has been most used to date, is to analyze the operational performance of a system, especially reflecting the environment and its effects on performance. Used in this way, the model enables the assessment of the most serious factors affecting performance, identifying which ones, given improvement, could most increase performance. The model also has a tendency to identify conceptual improvements which offer little or no improvement in performance once combined with all the other potentially degrading factors. This can be a most valuable analytical tool, most valuable indeed.